Under the old system of one special nurse, the patient received on the average about twelve hours actual service, the nurse taking three hours recreation, one hour for meals, and eight hours for sleep daily. I would suggest that the superintendent use two of her nurses to special each case as follows: First special nurse goes on duty at 7 a. m., off at 2 p. m. (seven consecutive hours). Patient is then under the care of the general or floor nurses three hours, or until 5 p. m. The second special nurse for the case goes on at 5 p. m., remaining until 12 midnight. Patient is then again looked after by floor nurses until 7 a. m. (Old system nurses slept during these seven hours.) It will be seen that by this method, the patient is cared for by the floor nurses during three hours, when under the old system the nurse usually took her three hours recreation and meals, and again from 12 midnight to 7 in the morning, or during the hours when the special nurse took her sleep. For the combined services of these two special nurses the hospital could charge $25 per week, without financial loss, and at the same time give good training in special nursing.

In conclusion: Many people are led to believe that hospitals are great revenue producers, and that most of them are run on a system of "graft"; these charges are both false. Well informed capital will not as a rule enter the hospital field as a money making investment.

Let me urge upon all hospital workers to join in an active progressive movement for general advancement of the hospitals of the State of California, that by interchange of thought, and co-operation we may accomplish the realization of *"The Ideal Hospital."*

IMPLANTATION OF JOINTS.*

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In 1908 Lexer reported to the German Surgical Congress two cases of resection of a firm ankylosis of the knee where he had implanted a new joint, taken from a limb amputated for senile gangrene of the foot. The joints were implanted immediately after amputation. They both healed perfectly into place and subsequently showed a fair range of motion. In one of these cases motion was at first hampered by adhesions of the patella to the femoral condyles. On reopening the joint three months afterwards in order to separate the adhesions Lexer had opportunity of observing the state of his graft. He found the joint intact in all its parts, the cartilage was smooth, in the joint cavity there were a few easily removable blood-clots. The implanted epiphyses had united firmly to the adjoining shafts so that not the slightest motion was possible. The crucial ligaments were well preserved, they even bled when scratched with the knife. A small section including cartilage, epiphysis and zone of union with the tibial shaft was chiseled out of the fibial part of the joint for examination. Microscopy showed that union had been brought about by firm connective tissue and by new bone; the cells both of the joint cartilage and of the implanted marrow stained well and were not necrotic. The following year Lexer reported that this patient had about 45° of motion and a firm, stable limb. Lexer has since performed a considerable number of similar operations, how many his scattered papers do not exactly state.

Goebell very recently reported the implantation of an unopened toe-joint into the finger to take the place of a joint resected for a severe arthritis deformans. The result was so good that the patient, a violin-player, was able to resume his occupation with a good movable finger.

The only American case of implantation of a whole joint of which I have been able to find a record is one of G. T. Vaughan in Washington. He attempted the transplantation of a cadaveric knee-joint after the resection of an openly suppurating tuberculous knee. This case was unsuccessful. The graft became the site of a profuse suppuration and the patient died a year and a half after operation. The cartilage had disappeared, and there was caries of the exposed part of the bone; about two-thirds of the implanted bone had been absorbed, but in spite of the unfavorable conditions under which it lay a large portion of the absorbed bone had been substituted by new growth from the ends of the patient's femur and tibia. I shall revert to a discussion of this important and interesting finding later.

These cases are the only ones I can find of implantation of a whole joint. Half joints have been frequently ingrafted, the most common indication having been that of tumor formation in the head of a bone calling for resection, where an epiphysis has been implanted to make good the defect. Perhaps the most extensive grafts of this kind are Küttner's two implantations of the femoral neck and head following resection for osteo-sarcoma. Küttner's cases have a bearing on those I should like to present to-night inasmuch as he took his material for implantation from fresh human cadavers. The cadaver as a source of material had already been suggested by Lexer three years before, but these were the first instances of its successful use. Küttner's first case was one of resection of the upper third of the femur for chondro-sarcoma. He filled the defect with a corresponding piece of a femur removed eleven hours after death from a man who had succumbed to a brain-tumor. The bone was preserved in Ringer's solution at 0° for 24 hours, making a 35 hours' interval from the time of death to that of implantation. The wound healed by primary intention, the patient walked without stick or crutch and had a considerable range of active motion. Eleven months after operation pulmonary and vertebral metastases began to make themselves apparent and these caused death 13 months after operation. The implanted piece recovered at autopsy measured 17 cm. from head to lower border, showed no traces of absorption and was firmly fixed to the femoral shaft at its lower end by a narrow ring of bony callus. The cartilage of the femoral head was almost entirely smooth, only the border showing some erosion.

* Read before the San Francisco County Medical Society, September 16, 1913.

The whole graft was covered by a membrane which could not be distinguished from true periosteum, and a new joint-capsule had formed around the head of the femur. The muscles inserted firmly to the bone at their normal sites. The second case, a similar one, remained cured for three years and two months, when a local recurrence forced Küttner to exarticulate at the hip.

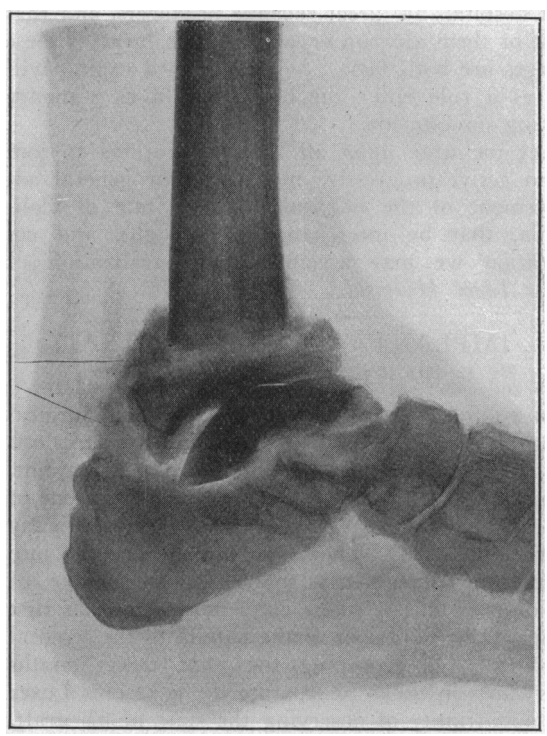
My own cases are as follows:

The first is that of a man 32 years of age, admitted to the City and County Hospital, Sept. 11, 1911. He had sustained an open, crushing fracture of the tarsal bones, had been operated upon several times with resulting suppuration, and came to the hospital with an ankylosis of the ankle, a resected astragalus, and a uselessly everted foot. He requested amputation, but when implantation of a joint was proposed consented to have it tried. Dr. Russell, in whose service he was, kindly let me have his care. On October 8, 1911, by the kindness of the Coroner's office, the cadaver of a man who had shot himself through the head 10 to 12 hours before, was placed at my disposal. This cadaver was of a very large bony frame, whereas my patient was of a slight build. In view of the fact, however, that it had been necessary to wait almost a month before getting an appropriate cadaver, I decided not to wait until chance should throw one whose bones were more nearly of a size into my hands. I removed about three inches of tibia and fibula together with the astragalus under strict asepsis, placed the bones in Ringer's solution, and kept them on ice at 0°. Several ccs. of blood were taken from the internal saphenous vein for cultures and for a Wassermann test, and some broth cultures were made of the marrow of tibia and fibula. The next morning at eight the culture-tubes were found sterile, and at 11 Dr. Schmitt reported a negative Wassermann test. Hereupon operation was begun, about 36 hours after the death of the donor of the bone. Under local anesthesia a firm bony ankylosis between os calcis, tibia and fibula was freed through a curved incision around the outer malleolus. Later an internal incision was added. The malleoli were resected and a V-shaped space gouged out of the os calcis for the reception of the graft. The cadaveric joint was removed from the Ringer's solution and freed of attachments of muscle, ligaments and tendons. The thin synovia at the front and rear of the joint was left. The bones were much too large for the man into whom they were to be implanted. While trimming them down they fell from the forceps of my assistant to the floor. In another case I should do all the trimming possible first and prepare the bed for the implant afterwards. Here, however, as I had already opened the patient's leg, I decided to attempt the use of the material at hand. I seared the graft in a large alcohol flame for five seconds and carefully cleaned it of all attached tissues, fat, etc., with frequent changes of instruments. As the joint still proved too long and too broad, it was necessary to reduce it until only the median parts of the malleoli and a thin slice of bone of the os calcis and of tibia and fibula were left. It was introduced into the cavity without undue tension and the soft parts united with catgut. The skin was closed without drainage. The leg was put into a cast.

For the first two days everything went well. Then the patient had a chill and developed a lymphangitis up the leg. This receded under alcohol compresses. A week after operation the cast was removed. The joint was not swollen and there was good healing except for a place at the inner side of the ankle from which thin sero-pus came. A forceps was unfortunately introduced into the joint at this place. On December 1st, about seven weeks after operation, suppuration from a sinus which had formed over the outer malleolus still continued; the inner sinus had closed. The new joint was still movable, but as the pattient had considerable pain in the sole of his foot, and as the suppuration did not seem to cease, amputation was decided upon and carried out.

The amputated foot was hardened in formalin, frozen and sawed open. The tibial portion of the graft shows firm fibrous if not bony union; it is firmly attached to the end of the patient's tibia and is of a healthy color. The cartilage is, however, yellow and necrotic. The lower part of the implanted astragalus is also firmly attached and is of good color; the upper part, however, is visibly necrotic. The cartilage of this part is also yellow, but has not exfoliated. Around the bones is a mass of callus thrown out by the remnants of the patient's tibial periosteum which surrounded the implanted joint. This same callus is visible in the X-ray plates of the amputated specimen. I think that careful examination of the X-ray as well as of the specimen itself will convince you that this callus is not thrown out by the graft itself, but by the patient's periosteum. One can still see the

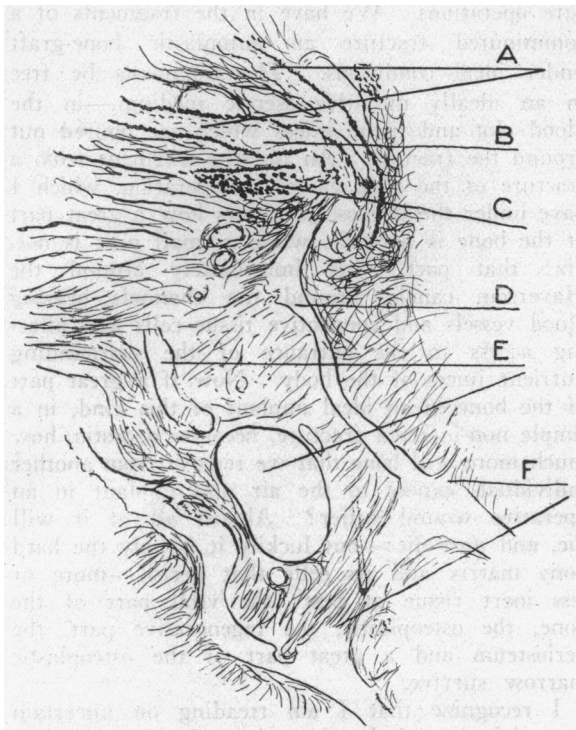
Fig. 1.



IMPLANTED JOINT. X-RAY AFTER AMPUTATION.

thin fibrous layer that divides the graft from the patient's bone and the callus is everywhere situated outside of this thin layer. The microscopic sections show the same thing. I suppose that the heat of the alcohol flame penetrated the deeper layers of the periosteum and injured them beyond repair. The microscopic sections bear out what inspection of the specimen and the good color of the implanted bone would lead us to suspect. We see that although the bony matrix of the implanted graft is dead, as it is in all cases of bone implantation, and contains no stainable bone-cells, it is

Fig. 2.



A—Invading spicules of new bone, with border of osteoblasts; the lacunae contain well-stained cells.

B—Small island of necrotic bone in midst of live bone (lacunar cells unstained).

C—New osteoid tissue.

D—Spicules of necrotic bone, cells of lacunae unstained.

E—Bloodvessels of marrow.

F—Connective tissue fibrils going over intimately and insensibly into dead bone.

SECTION FROM EDGE OF GRAFT, SHOWING PROCESS OF SUBSTITUTION.

everywhere surrounded by living fibrous tissue. Evidences of round-cell infiltration, of suppuration, and of sequestration are wanting over great areas. We see the fine connective tissue fibrils running directly over into the spicules of dead bone and intimately joining them, not encapsulated around them as around a foreign body. And we see the thin fibrous layer that separates the graft from the patient's tibia everywhere pervaded and invaded by new bone in all stages of formation, by osteoid tissue, by osteoblasts, by all the products of the endogenous callus, of the osteoblasts of the marrow. I should like to call these points to your special attention: This intimate connection and pervasion of the spicules of apparently dead bone by new connective tissue, and the invasion and substitution of the graft by new bone formed from the elements of the marrow. It is here that the living graft shows its superiority over the implant of dead and foreign material. Even under the most unfavorable conditions and in the presence of suppuration all is not lost, the implanted bone where it is absorbed is everywhere substituted by living bone formed from the patient's osteoblastic material, a great part of the graft is organized, and there is little evidence of sequestration. Vaughan's case, referred to in the beginning of this paper, showed the same findings under still more untoward circumstances.

If the graft does not remain alive as a whole it is at least not cast out, it remains a part of the organism into which it is transplanted, and this, after all is what we are striving for;—this is the practically important point; whether the microscope shows life or death of the bone is really a matter of more or less academic interest only; what the patient wants is that it stay in place and do its work,—and this it does.

My second case was more successful. It is that of a man 28 years of age. He was admitted to the City and County Hospital under Dr. Russell, to whom I first owed the privilege of attending him. He had an extensive cellulitis and teno-synovitis of the hand which I treated with multiple small incisions. The hand healed, but the man had a stiff joint at the base of the ring-finger. He passed from my care as I left the Polyclinic service and an arthroplasty was carried out by two other surgeons. This did not result in giving him a movable joint. He then went to work as an orderly in the hospital, and I owe his subsequent care to Dr. Mackintosh, resident physician. On July 26th I removed a knuckle-joint aseptically from the cadaver of a man who had died of heart disease 12 hours before, and placed it on ice in about 4 ounces of salt solution. On July 28th Dr. Schmitt reported that the Wassermann test had given no more inhibition than was usual with cadaveric sera. The blood cultures had remained sterile. I therefore proceeded to the implantation that same morning, 60 hours after the death of the donor. I resected the firmly ankylosed joint at the site of the previous arthroplasty, and inserted the graft, fixing it in place with two stout catgut sutures passed through drill holes in the ends of the bone. I put the man's hand and forearm in a splint and applied a traction of 1½ pounds to the finger. The wound healed well. At the time of the first two dressings a little blood-serum came from the wound. It has since remained closed. Passive and gentle active motion was begun about 10 days after operation. Traction was continued for a month, at first continuously, then only at night. The patient now has about 35° of active and 60° of passive motion in the joint. There is firm bony union. The X-ray shows a good callus formation. How much of this has come from the graft and how much of it from the patient's bone I do not think that it is possible

to say in a case of the kind where there is always a probability that the graft was placed in a bed whose walls contain remnants of periosteum. The joint surfaces seem to be smooth, there is no rubbing to be felt, nor does the X-ray show any roughness here. Much of the limitation of motion is due to adhesions and fixation of the soft parts, the remains of the old purulent teno-synovitis. The patient is steadily improving, and I hope that time and use of his joint will give him good motility. The resected joint, the site of the previous arthroplasty, showed a firm fibrous, but not a bony union. The tissue forming the union contained fibro-cartilage in places, and in its center a small bursa, the size of a lentil.

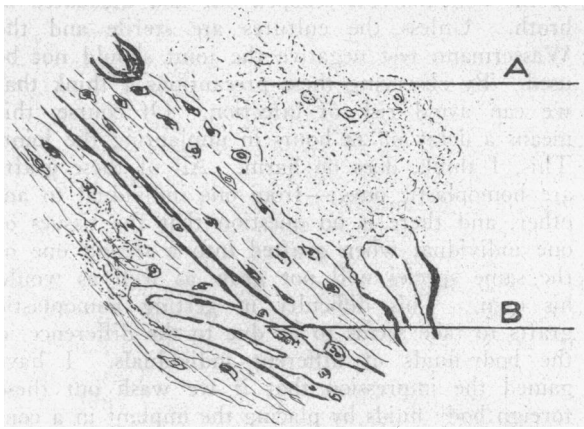
These cases open a mine of interesting problems. The first question that presents itself is, what becomes of the implanted bone, is it alive when implanted, and does it remain alive in its new host? This is, of course, the vital question, for if it is dead or dies then the query arises whether we may not as well go back to the era of foreign body implantation, and put in boiled or decalcified bone, celluloid or similar substances. Nothing, I think, is more interesting than the history of this controversy, and nothing shows more plainly how much modern practice lies under the ban of the laboratory experiment. What can be more striking than to see how Ollier's researches of the '60's and '70's, which showed the importance of periosteum in bone-formation, were followed by the careful subperiosteal resections of v. Langenbeck and his school, and by the early successful bone-transplantations, where care was taken to preserve the bone-forming membrane intact. What more vivid illustration of the far-reaching effects of an erroneous observation than to see how Barth, experimenting with grafts of the bones of the skull in dogs came to the conclusion that the whole of the implant dies, and how thoroughly the next decade was imbued with his views. If the implant dies anyway, why go to the trouble of securing a living graft? What more natural conclusion? And following it we find the period of the implantation of celluloid, silver plates, decalcified bone and other foreign bodies. Transplantation of living bone was almost universally given up;—but a very few surgeons had enough confidence in their own powers of clinical observation to imagine that the laboratory could be wrong, and that living bone was better than celluloid, or dead bone even. It is interesting to see how the studies of Axhausen, published five and six years ago definitely settled this point at least;—that *part* of the implanted bone lives and remains alive, and led us back again to our modern era of bone-transplantation, of transplantation of the living graft.

Axhausen would have it that although the greater part of the implant, viz: most of the solid bone, dies, a certain part lives, viz: the outer, immediately subperiosteal layers, and the inner, cancellous subendosteal layers;—and furthermore and most important of all, that these bone-forming membranes, periosteum and endosteum themselves remain alive and proceed to form new bone.

I think that this is true in the main,—one can easily verify many of these facts by studying microscopically fragments of bones extracted in fracture operations. We have in the fragments of a comminuted fracture an autoplastic bone-graft under ideal conditions. The fragments lie free in an ideally nutritive aseptic medium,—in the blood clot and tissue juices which are poured out around the fracture. An isolated fragment from a fracture of the tibia gained at operation, which I have under the microscope shows how a great part of the bone is necrotic, while a small part is not, viz: that part lying immediately around the Haversian canals, around the channels bearing blood vessels and connective tissue cells and offering access to the entrance of the surrounding nutrient juices of the body. Now if a great part of the bone in an ideal implant of this kind, in a simple non-infected fracture, becomes necrotic, how much more will bone that we remove from another individual, expose to the air and implant in an operative wound suffer? Almost all of it will die, and *does* die;—but luckily it is only the hard bony matrix and its cells that perish,—more or less inert tissue at best; the vital part of the bone, the osteoplastic, the regenerative part, the periosteum and a great part of the osteoplastic marrow survive.

I recognize that I am treading on uncertain ground here, and that I am in entire disaccordance with Macewen's opinions. Macewen denies all bone-forming power to either periosteum or endosteum, and regards the bone-cells themselves, the cells of the lacunae as the regenerators of bone. I do not think that this can be denied a priori. The cells of the lacunae are certainly closely related to those of the periosteum. They are derivatives of the cambium layer of periosteal osteoblasts, are these cells themselves in fact, in a later stage of development, and there is no ground for denying the assumption that were it possible to free them of their hard osseous envelope and reinvest them with the possibility of free proliferation and expansion, that they could revert to their primary state and reform bone. There is no a priori reason for denying this assumption, but I do not think that it has been proven. There is not a bit of microscopic evidence in all of Macewen's book, and it is only on miscroscopic evidence that this controversy can be settled and the growth and formation of bone be elucidated. Until Macewen gives us such I think that we must regard his theory of bone formation by the cells of the lacunae as unproven. That new bone is thrown out around bone-shavings, or even by them proves nothing, even minute fragments of bone carry with them endosteal osteoblasts and the osteoblastic layer of the Haversian canals, new growth of bone may take place from these elements as well as from the cells of the lacunae themselves. So that I do not think that we are in a position as yet to finally answer this question of "What keeps the bone alive?" If, however, we ask *"Does* the implanted bone stay alive?" then I think that we can state that enough of it does at any rate to lead to a perfect regeneration and reformation throughout its substance, and that *this regenera-*

Fig. 3.



A—Disintegrating bone, lamellar structure gone, some shadows of empty lacunae still visible.

B—Haversian canal, bearing bloodvessels, neighboring bone shows lamellar structure, most lacunae contain well-stained cells.

FRAGMENT FROM COMMINUTED FRACTURE OF TIBIA.

tion takes place in part from the elements of the graft itself. This is the vital point, and the reason that a living implant is so much superior to a dead one.

That much of the compact bone becomes necrotic is a matter of indifference. We have to differentiate clearly between necrosis and sequestration. This distinction is not made nearly clear enough. In talking over my first case of joint implantation with a surgeon the other day, he related a similar instance where the graft had fallen to the floor and where he had immersed it in iodine. It was evidently alive he said, "because it is now several months since operation and it hasn't come out." Now that has nothing to do with its being alive. That the piece stays in does not prove whether it is alive or dead. Why should it come out if it is dead, provided it is aseptic? Catgut and Lane plates, and silver wire are surely not alive, and yet they do not come out. So that the fact that a large part of our bone-grafts, almost all of the compact bone, becomes necrotic need not lead us astray. It will not come out if it is aseptic, and sometimes not, even if it is not. The slide shows this beautifully. Here we have a bone-graft under the worst possible conditions, a large mass of bone in the presence of infection, and yet in many parts we see these necrotic bony spicules intimately attached to the surrounding scar, the fibrils of new connective tissue growing over almost insensibly into the implanted bone, and we see around them no evidences of round-cell infiltration nor of other effects of the organism to rid itself of this necrotic tissue as of a sequestrum nor yet a thick fibrous encapsulation as around an aseptic foreign body. Why this apparently necrotic bone acts in this way I do not know. As far as the microscope can say the bone is certainly necrotic, its cells do not stain, the lacunae are apparently empty, the matrix is finely granular, and yet we find no evidences of sequestration, round-cell infiltration or encapsulation as always appear around a silver wire or a silk thread or other foreign body. This is remarkable enough, and herein lies the superiority of the living graft over all other material we may implant.

Another interesting problem: Are not these implanted joints liable to subsequent degeneration, to deforming joint affections? We know that deforming arthritis may be induced experimentally by making an aseptic necrosis of the joint cartilage and the underlying bone. Some observers have even gone so far as to seek in this aseptic necrosis the primary etiologic factor in the production of deforming arthritis. If, then, in the most successful of grafts we have large masses of necrotic bone and some necrotic cartilage, will not the implanted joint be the seat of a subsequent deforming arthritis? Küttner's cases answer this question better than all theoretical discussion. In his extensive implantation of the upper third of the femur he found no arthritis when the case came to autopsy 13 months after operation. And you will concede that this joint—the hip, particularly predisposed to arthritis, and this extensive graft, containing over 6 inches of massive bone, should offer ideal conditions for an arthritic degeneration. My finger-joint appears perfectly smooth two months after operation, although it is, of course, too soon to say whether it will remain so. Time and a wider experience will answer this question of arthritis.

I will not take up more of your time with these theoretical problems.

As to the choice of procedures. Implantation of joints has its chief rival in arthroplasty as developed by Murphy. While the indications for each may leave some room for discussion, each has a field of its own. The Murphy operation has certainly the advantage of utilizing the patient's own tissues, and doing away with the implantation of a mass of foreign even if living material. It does not involve search nor waiting for a donor, be this a cadaver or a living patient. It runs less risk of infection, always a possibility with cadaveric material. On the other hand there are certain cases where Murphy's arthroplasty would not be feasible. In ankylosis of the knee after injury, with extensive crushing and scar formation in the

soft parts, for instance. And particularly in implantation of half-joints after epiphyseal resections for malignant growths; here we must implant in order to get a useful limb. It is too early to compare the definite results of the two procedures. In one case at least, my second, transplantation has given a promising result where arthroplasty had failed.

As to the source of material: There are two possibilities; amputated aseptic limbs, and the cadaver. Few of us have an amputation material large enough to rely upon. Lexer performed a number of high amputations for dry senile gangrene which put fresh aseptic joints at his disposal. Aside from the fact that many would prefer a more conservative course in these cases, this material necessarily has its limitations. It will never put us in possession of a hip-joint. Besides dry gangrene is rather rare in this country. The material of a railroad hospital, with a number of high crushing injuries of the limbs might make a further number of aseptically amputated joints available. Still I think that there can be no question that cadaver material is more easily procured. It has, of course, a number of disadvantages; the risk of infection first, and a certain aversion, more or less sentimental perhaps, to the use of cadavers,—on the part of the surgeon to implanting mortuary material, and of the patient to carrying it about in his body. This may be serious enough at times. One of Lexer's patients, a Russian, became so obsessed by the idea that he was carrying a dead man's bones about in his flesh that he had no rest until the perfectly successful graft was amputated. However, the risk of infection stands foremost. This is not as great as it might seem if proper restrictions are observed. Bergemann made bacteriological examinations of the bone-marrow from the femur and tibia in 20 cadavers, among them many who had died of infectious disorders such as peritonitis, pulmonary gangrene, etc. All cultures taken up to 24 hours after death showed no growth, but one, which was sterile 24 hours after death, showed a growth 44 hours after, and this was a case of diabetic gangrene. Personally I should not like to use the joint of a man who had died of a disease in which infection played any part whatsoever for implantation.

I should like to urge the following precautions: The joint should be removed as soon as possible after death, preferably within the first 12 hours, certainly within the first 24. Decomposition must not have set in; the body should have lain in a cool place. The cause of death must have been a non-infectious one; preferably accident or injury, apoplexy or sudden heart failure would also offer suitable material. Death should have occurred quickly without long agony. The reason for this is that patients who are long moribund often develop pulmonary edema and broncho-pneumonia, and with them we run a certain risk of a terminal pneumococcic septicemia. Simultaneously with the removal of the joint blood should be taken from a vein of the limb central to the joint for a Wassermann reaction and for culture, and portions of the bone-marrow scooped out and incubated in broth. Unless the cultures are sterile and the Wassermann test negative the joint should not be used. By observing these precautions I think that we can avoid risk of infection. Of course, this means a delay of 24 hours in implanting the joint. This, I think, does no harm. All of these grafts are homoplastic ones;—from one individual to another, and there is no question that the tissues of one individual when grafted into a second one of the same species will not grow as well as would his own. This difficulty in getting homoplastic grafts to take seems to be due to the difference in the body-fluids of different individuals. I have gained the impression that if we wash out these foreign body fluids by placing the implant in a considerable quantity of sterile Ringer's solution for 24 hours the grafts take better. I have not enough evidence to state this positively, but I have the impression. If further experiments prove corroborative this would be a finding of some importance.

The bones should be freed of all adherent tissue, muscles, tendons, ligaments, fat, etc., before implantation. The multiple small incisions into the periosteum which their removal entails are of advantage. Adherent muscle or fat impedes the access of nutrient plasma and blood vessels, and imperils the life of the graft. Whether or not to take the synovial capsule with the joint is a question. Lexer advises against it, and suggests a secondary implantation of this membrane should a new capsule not form around the graft. There are arguments both for and against a primary implantation of the synovia. Synovia certainly impedes access of the body-fluids to the joint surfaces, and introduces a rather delicate tissue into the wound, on the other hand it prevents the proliferation of new connective tissue into the joint and erosion of the cartilage by this pannus. These considerations may be more theoretical than practical. Lexer not including synovia found no overgrowth of the cartilage by connective tissue, and in one case where he did implant synovia the wound began to break down two months after operation, and signs of sequestration and extrusion of the graft began to appear. Küttner found that a new capsule had formed around the head of the femur which he implanted. In my first case I intended to use the synovia, but had to remove most of it in order to make the joint fit. In my second case I implanted the synovia with success. I think that its use may probably be indicated in smaller joints, but that in larger ones, where large masses of bone are used, it had better be trimmed off.

A few words as to technic. Perfect asepsis is a sine qua non. The skin of the cadaver is scrubbed with pure lysol. A flap of skin is outlined and turned back out of the way. The joint with enough additional bone on each side to furnish material for a skewer if need be, is removed, placed in sterile Ringer's solution and kept on ice. Blood is withdrawn from a vein above the joint for a Wassermann reaction and culture. Some bone-

marrow is scooped out, placed in broth and incubated. The patient is prepared with iodine, and is operated upon the next day, if cultures and Wassermann test prove negative. A semilunar or horse-shoe flap of skin is outlined about the site of the proposed implantation, care being had that the incisions of the skin and the underlying soft parts are not superimposed. If they are there is danger of leakage and subsequent sinus-formation. Adherent tissues are trimmed off the periosteum, and the bone sawed through as close to the joint as the exigencies of the case will permit. I think it best to implant as little adjoining bone as possible in order to limit the amount of foreign material and to hasten the pervasion of the dead compact bone by substituting callus. If possible the ends of the bones to be grafted and the ends of the patient's bones are shaped so that they will fit securely and hold themselves in place automatically. This may be done by cutting them to a V-shape, or if practicable, mortising them. The joints are very slippery as my disastrous experience with my first case taught me. When working with them a large basin or sheet should be placed beneath the operator's hands, so that if the joint does slip it will not fall to the floor. The bones are held in place by means of stout catgut passed through drill-holes. The holes should be drilled, and loose loops of catgut passed through them before inserting the joint into its seat. It is easier this way, and the catgut will prevent the joint slipping from the operator's hands during the manipulations necessary to force it into place. Wire, staples, nails or other dead material should not be used for fixation. If catgut will not hold a skewer of periosteum-covered bone may be used. The soft parts are carefully approximated to and about the joint with catgut, and the wound closed without drainage. It is covered with gauze moistened in campho-phenol, which makes a good antiseptic dressing and cakes with the blood that oozes from the wound to make a splint. Long adhesive plaster strips for traction are applied all the way up the limb, and the whole is put up in a splint or in plaster of paris. Traction is put on as soon as the patient reaches his bed. Gentle passive motion is used in about a week. Early motion is encouraged, massage, etc., not neglected. Traction is kept up for a month or longer; after the first fortnight it may be left off during the day and used at night only. While motion is encouraged, the implanted joint should not bear weight for a considerable time. Lexer advises six months for the knee-joint. In the course of after-treatment various mobilizing procedures, muscle- and teno-plasties, etc., are often necessary in order to reestablish satisfactory function.

To Conclude:

1. Implantation of joints is a feasible and useful procedure.

2. Much of the implanted bone becomes necrotic; it is not shed, however, but amalgamates, and is absorbed and replaced by living bone.

3. A small part of the implanted bone remains alive, viz: the superficial inner and outer layers.

4. Much of the implanted periosteum and endosteum remains alive, and is probably the source of the new bone.

5. A subsequent arthritis deformans does not seem to develop in the new joints.

6. The fresh cadaver is the most practicable source of material.

7. Only fresh cadavers of patients who have died suddenly of a non-infectious disease should be used.

8. Absence of infectiousness should be assured by bacteriological and serological tests.

Discussion.

Dr. J. Rosenstirn: I have seen the cases of joint transplantation shown by Lexer in Berlin, at the annual meetings of the German Surgical Society, but have had no personal experience myself. I can only congratulate Dr. Eloesser upon the very excellent result in the transplantation of that small joint. I am sorry that the other was spoiled by the inattention of his assistant, as I suppose that, under other circumstances, he might have had an equally good result.

Dr. Harry M. Sherman: In the case of a lacking phalangeal head, I once planned to transplant the head of a toe phalanx into the hand, and it seems to me that this would be the more obvious thing to do because of the greater expectation of satisfactory healing and function in the case of homoplasty instead of heteroplasty. I was not permitted to do the operation, consequently I have no result to report.

Dr. S. L. Haas: I would like to ask if the transplantation of a piece of bone with attached cartilage is to be considered as the transplantation of a joint.

Along the line suggested by Dr. Sherman, there has lately been reported by Goebel the transplantation of a phalanx of a toe in toto to take the place of a diseased phalanx of the finger. After one year he reports a successful result. The same has been done in making the bridge of the nose. Murphy transplanted the whole phalanx of the toe into the nose. After one year the entire graft disappeared, which he ascribed to the failure of obtaining apposition of bone with bone.

It seems to me that in the cases reported you are not really transplanting a joint but that it is simply transplanting a piece of cartilage and bone. It is interesting to study what happens to the periosteum, cartilage and bone in these transplantations. Some experimenters report that the perichondrium and the underlying cartilage remain alive but that the deeper cartilage disappears.

In the case of Dr. Eloesser's patient, if you resected the end of the metacarpal you could also obtain a movable finger. The resistance at the base of the finger is removed but by applying extension for several weeks a fairly useful finger results.

I have had a couple of cases of diseased phalanges with stiff joints in which I resected the middle part of the phalanx up to the articular cartilage, and then transplanted a piece of healthy bone into the defect. In one case flexion of 30° and in the other of more than a right angle was obtained. It is interesting in these cases where you remove everything up to the thin cartilage plate, then interposing a piece of bone that you get union, and in time the formation of a new phalanx.